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FABRICATION OF GLASS SPHERES FOR LASER FUSION TARGETS*

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ABSTRACT

We have developed processes for mass producing the quality glass microspheres required for current laser fusion experiments. We describe the advances in the methods and materials used in our liquid droplet and dried gel systems.

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The glass-microsphere specifications for laser fusion experiments are very stringent. Acceptable shells must meet a diameter tolerance of $\pm 5 \mu\text{m}$, a thickness tolerance of $\pm 500 \text{ nm}$, a wall thickness uniformity of 200 nm , and a surface smoothness of better than 50 nm . Because the glass microspheres undergo several additional processing steps, such as coating, we also need batches in which 80% of the spheres meet all of the requirements. Successful production of high quality glass microspheres requires understanding and control of both the physics of sphere formation and the chemistry of glass. Our processes give us the required control over glass composition, microsphere mass, and formation sequence.

In our liquid droplet process,⁽¹⁾ we produce uniform droplets of an aqueous solution of glass-forming compounds by acoustic disintegration of a liquid jet and then pass them through a long vertical furnace where they blow and fuse into hollow glass microspheres. The percentage of solids in the solution, the size of the jet orifice, and the acoustic driving frequency determine the size of the liquid drops and the mass of the resulting microspheres. The furnace temperature profile and air flow, in conjunction with the drop size, determine the diameter, wall thickness, and uniformity of the spheres. When properly tuned our systems produce batches of spheres in which more than 90% of the spheres have the same diameter and wall thickness within $\pm 10\%$. In addition, more than 90% of the spheres within a batch satisfy the exacting surface and symmetry specifications.

To expand our range of compositions and available sizes we use a dried-gel process in addition to the liquid-droplet method to make hollow glass microspheres. In the dried-gel process^(2, 3) a solution containing glass-forming oxides is dried and ground into fine particles. The powder, after sieve cutting for the appropriate size granules, is dropped through a furnace. The water of hydration in the gel is encapsulated and the oxide particles blow and fuse into hollow glass shells. Unlike the droplet system a wide distribution of spheres is produced due to the varying initial particle size. When necessary we diameter and density sieve cut to narrow the size distribution. By adding urea to the gel which acts as an additional blowing agent we can produce large-diameter, thin-walled spheres ($\sim 500 \mu\text{m}$ O.D. X $.5$ to $1 \mu\text{m}$ thick).

We recently succeeded in filling spheres made in the dried gel system with argon as was done in the past with spheres made in the liquid-droplet system.⁽⁴⁾ We are now in the processes of filling the spheres with bromine.

In both processes we use low melting point glass compositions that give us uniform spheres and smooth surfaces. Currently our glass consists of 70.6 wt. % silicon dioxide, 21.0 wt. % sodium oxide, 2.0 wt. % boron oxide, 5.4 wt. % potassium oxide, and 1.0 wt. % lithium oxide. For future applications we are experimenting with lead glass compositions.

Once the glass microspheres are formed, it is vital to remove all of the reactive alkali and to passivate the surface to prevent its rapid deterioration on exposure to humid air. We developed a special acid wash procedure that yields surfaces much smoother than the required 50 nm.

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